



# Alaska's Cold Desert

DAVID MECH, NATIONAL BIOLOGICAL SURVEY

**A**t first glance, arctic Alaska may appear to be a barren wasteland. Yet, in reality, this cold desert teems with life. Myriad plants and animals are native to this treeless plain above the Arctic Circle. In summer, the upper part of the ground (about 10 centimeters) thaws for just a short period, triggering frantic activity for the region's denizens.

This area is resource "rich" in many ways. One of the world's largest oil fields, for example, is located at Prudhoe Bay, Alaska. Oil from that site travels southward more than 1,200 kilometers to Valdez, Alaska, through the Trans-Alaska Pipeline. Oil from Prudhoe Bay accounts for about a quarter of total U.S. oil production.

In this article and on the accompanying foldout, we explore the unique features of Alaska's arctic ecosystem, with a focus on the special adaptations of plants and animals that enable them to survive in a stressful climate. We also review the challenges facing public and private land managers who seek to conserve this ecosystem while accommodating growing demands for development. With the classroom activities we've included, you can help students understand why fragile arctic soils are slow to recover once disturbed; why arctic animals look so different from their desert counterparts; and how to evaluate the pros and cons of oil development along the arctic coast, an issue that will likely be debated into the 21st century.

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*By Jeff Brune, Robert King, Mike Kunz, Richard Brook, and Mary Tisdale*



## Three Regions

Arctic Alaska, the area of the state north of the Arctic Circle, has three distinct regions: the arctic coastal plain, the Brooks Range, and the boreal forest with its numerous lakes, rivers, and streams.

The arctic coastal plain, or the "North Slope," includes 14 percent of Alaska's land. Blanketed by tundra and dotted with lakes and ponds, it receives less than 16 centimeters of moisture annually (less than the Mojave Desert). Despite meager precipitation, most of the coastal plain is classified as wetlands. The underlying permafrost (permanently frozen ground) inhibits drainage, and the small amount of melt water or rain that soaks into the tundra remains near the surface. Most inhabitants of the North Slope live in one of eight communities, seven of which are along the coast. The largest communities are Barrow and Kotzebue. Barrow, at about 1,300 kilometers from the North Pole,

is the northernmost inhabited village in North America.

South of the North Slope lie the rugged peaks of the Brooks Range, which runs across northern Alaska for 1,150 kilometers. The range rises over one kilometer at its western end, and nearly three kilometers in its eastern peaks. Although white spruce and other trees appear in some sheltered valleys, the slopes are generally bare except for a thin layer of hardy tundra

vegetation, such as lichen. From the highest peaks, rivers flow south to the Yukon River, north to the Beaufort Sea, or west to the Chukchi Sea.

The south slope of the Brooks Range, sheltered from ocean winds,

grows more varied tundra vegetation and forests of small trees. The Russians called this region "taiga," a land of scattered dwarfed conifers, and for good reason: Trees grow so slowly in the taiga that scientists have measured century-old spruces with trunks no more than 30 centimeters in diameter. The average white spruce in the taiga is only six meters high, even after a century of growth.

## Adaptations

In order for arctic animals to survive in their arid, windy, and frigid environment, nature has equipped these creatures to find food and shelter and to produce offspring. The accompanying foldout highlights many of the unique adaptations of arctic plants and animals and provides activities that can help students understand how adaptations work.

Arctic Alaska's human inhabitants have also adapted to cope with the environment. With temperatures averaging well below freezing during most months, the need to stay warm is paramount. Semi-subterranean "pit" houses were used from prehistoric times until recently. These homes, built of sod and other natural insulation, were very efficient at holding in the heat. Modern arctic houses now resemble those in the lower 48 states, yet contain more insulation and are often built on pilings to allow cold air to circulate under the house. This ensures that the warmth of the house won't melt the underlying permafrost and cause the structure to sink.



A whale harvest in Barrow, one of the eight communities of the North Slope.



The rugged peaks of arctic Alaska's Brooks Range rise from one to three kilometers.

## Ongoing Management Challenges

Over two-thirds of arctic Alaska is federally owned land, managed by the Bureau of Land Management, the U.S. Fish and Wildlife Service, and the



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*Brilliantly colored flowers bloom in the arctic summer.*

National Park Service. Americans depend on these agencies to properly manage Alaska's tundra regions to meet a variety of human and environmental needs. In meeting their responsibilities, these agencies are grappling with a number of tough environmental challenges and issues.

**The Fragile Tundra.** The soils of the Arctic are very susceptible to damage if disturbed by animals or humans. Some biologists estimate, for example, that it may take up to 40 years for lichens to recuperate from the munching and treading of a passing herd of caribou (some lichen growth has been measured at a sixth of a centimeter per year).

The land of the North Slope is underlain with permafrost, insulated on top by shallow-rooted, low-lying vegetation. In the summer, the sun's radiant energy thaws the frozen surface down about 10 centimeters, with the melted snow water unable to seep into the frozen ground below. Consequently, the region is largely wet and boggy, with over a million shallow lakes. Crossing the terrain by foot in the summer is difficult, because the surface consists of areas of elevated grassy tussocks alternating every 10 centimeters

with small, sunken pools of stagnant standing water.

As long as the permafrost is insulated from heat by the surface vegetation, it can remain stable for many thousands of years. On the other hand, even small disturbances to the vegetation rootmat can start a process of destabilization that can reach impressive proportions.

Experience has taught us about the fragile nature of this land. In the post-World War II period, exploration for oil and gas involved the use of mechanized vehicles that damaged the insulating vegetation. When the vegetation was damaged, the permafrost was no longer insulated from the summer sun, causing the frozen soil to melt. Eventually, this resulted in massive artificial bogs and swampy areas. In some places, these scars, though decades old, are still evident.

Crossing the tundra without damaging the permafrost is an ongoing challenge. Much of today's permafrost degradation is triggered by road-building and other construction activities that strip away or disturb the vegetation.

Over the years engineers have learned to work in winter and to avoid disturbing the vegetation. For example, in building the Dalton Highway, an all-weather road that extends north 650 kilometers from interior Alaska to the Prudhoe Bay oil fields, engineers placed the roadbed on top of the vegetation rather than cutting into the surface as is the common practice in road-building. In some areas, sheets of plastic-foam insulation were placed on the vegetation to provide additional thermal protection before the roadbed material was laid down. Moreover, mechanized vehicles may use the road only in periods of adequate snow cover

(15 or more centimeters) in order to blunt the impact on the tundra. In other cases, temporary ice roads are built. Even air-cushioned vehicles have been tried as a way to avoid damaging the tundra.

Unfortunately, despite innovations in road and building construction, the fragility of the tundra remains a paramount issue in the Arctic today. Other concerns in the region include ozone depletion, solid waste disposal, and pollution of the Arctic Ocean.

**Ozone Depletion.** The effect of ozone depletion is of particular importance to life in the Arctic and Antarctic, as the phenomenon is most severe over polar regions. In the winters, "ozone holes" develop over the poles. Research points to certain



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*A summertime view of the North Slope's Kanuti Flats shows why the region is considered a wetland.*

human-made chemicals, chlorofluorocarbons, being major contributors to this situation. Researchers in the Arctic are investigating how plants that support the food chain may be impacted by ozone depletion.

**Solid Waste Disposal.** Disposing of solid waste is another major problem in the Arctic because permafrost limits the construction of sanitary landfills, and low temperatures inhibit bacterial decomposition of organic wastes. Scientists have detected the effects of human wastes from Inupiat (native

Alaskan) settlements centuries after the inhabitants have gone. Today, organic waste is collected and hauled to sewage dumping areas or burned in oil barrels.

### Pollution of the Arctic Ocean.

Recent reports of nuclear waste contamination and massive oil spillages from broken pipelines in Siberia have once again raised concerns about pollution of the Arctic Ocean. The oil spillages have been near river systems that drain into the Arctic Ocean. Because the Arctic Ocean is a major source of fish, whales, seals, and walrus (of cultural and economic importance to local



L. DAVID CARTER, U.S. GEOLOGICAL SURVEY

*Musk oxen stand in a defensive posture. These animals were exterminated from the North Slope in the late 1800s by sport-hunters, but 64 musk oxen reintroduced into the coastal plain in 1969 and 1970 have now multiplied to a thriving population of 550.*

Inupiat), the consequences of polluting it would severely affect the human population as well as the environment in general.

**Global Warming.** About 14,000 years ago, arctic Alaska's climate began to change. Although the reasons for the change are not completely understood, the major factors of solar radiation, the winds of the jet stream, and ocean current fluctuation were involved. This climate change resulted in a major alteration in nature and caused the extinction of most of the Ice Age herbivores as well as the carnivores that preyed on them. A few large predators, such as the grizzly bear and wolf, survived, as did a few of the less common Ice Age herbivores that were

better suited to the new ecosystem than the old one, such as moose, musk oxen, and caribou. It was a difficult time for the human population also, because of the declining food resources and the fluctuating climate.

Some scientists predict that the results of global warming over the next century will be very similar to the effect of past warming events on the permafrost and on the arctic ecosystem. Of special concern is the peat that lies beneath the tussock-tundra covering most of arctic Alaska, Canada, and Russia. These arctic peat deposits contain huge amounts of  $\text{CO}_2$ ; if the climate warms enough that the peat thaws and begins to decompose, all of that  $\text{CO}_2$  would be released into the atmosphere. The increase in atmospheric  $\text{CO}_2$  could cause an increase in surface temperatures, which in turn could cause the rate of peat decomposition to accelerate, generating more  $\text{CO}_2$ . The onset of an ever-increasing  $\text{CO}_2$  production cycle in the Arctic could have a significant effect on ecosystems worldwide.

Ironically, a climatic alteration that brought the first humans to North America thousands of years ago may provide insight into a contemporary climatic change that could affect modern humans and alter the course of civilization once again.

## Arctic National Wildlife Refuge

The 7.7 million-hectare Arctic National Wildlife Refuge, commonly referred to as "ANWR" (pronounced "anwar"), is the nation's largest wildlife refuge. ANWR supports 169 species of birds, 38 species of fish, 44 species of mammals, an unknown number of species of flowering plants, and more than 2,000 species of lichens and bryophytes (mosses and liverworts).

In recent years, Congressional debates about allowing oil and gas

development in ANWR have brought attention to this issue. The question is, What are the impacts of oil and gas development, including pipeline construction, on wildlife and on the Inupiat and other northern peoples who subsist, in part, on this wildlife? Opinions vary on the answer, with some people predicting little effect, while others foresee drastic impacts brought about by substantial changes to the migration and calving patterns of caribou.

At stake for consumers is the nation's most promising onshore petroleum prospect. Geologists have determined that there is a 19 percent chance of finding recoverable oil deposits within ANWR's coastal plain. No one knows how large the potential oil reservoir is, but federal land managers estimate there may be enough oil in that field to supply at least 10 percent of the nation's fuel for the next 20 years.

At stake for conservationists is the biologically productive arctic coastal plain. Often referred to as "America's



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*Inupiat children from the village of Wainwright on the arctic Alaskan coast brave a howling winter storm.*



FRED HIRSCHMANN

The Trans-Alaska Pipeline near the Richardson Highway. This line carries oil from Prudhoe Bay to Valdez.

Serengeti," the coastal plain

- serves as an important calving ground for the Porcupine caribou herd;
- contains about 75 percent of the year-round musk ox range;
- provides an important gathering area for more than 100,000 lesser snow geese;
- is frequently used for maternity dens by polar bears in winter;
- and is used by birds from six continents, who flock there to raise their young.

Research may help answer some of the issues surrounding ANWR, but politics and the worldwide price of oil will no doubt strongly influence the progress of development in this part of the world.

## Recreationists

Primarily as a result of the ongoing debate about the future of ANWR, an increasing number of wilderness adventurers have been visiting the refuge to see for themselves what the debate is about. The number of outfitters offering backpacking and river trips increased from one in 1975 to 15 in 1995. One result has been that the amount of river usage during the short summer has increased dramatically. A "visitor-use day" indicates one

person using an area for all or part of a day; in 1984 ANWR had 702 visitor-use days, and in 1995 it had 3,182 visitor-use days. As a result, congestion on the rivers and air traffic in and out of the refuge have grown. As recreation use intensifies, so will impacts on the ecosystem, and decisions will have to be made on whether to limit access to ANWR.

## Looking to the Future

Alaska's tundra seems immense, remote, and largely untouched by humans. Yet, as the human population in this region increases and as resource

development grows, human actions will have a long-lasting and cumulative impact in the ecosystem. Meeting the needs of people today while protecting our resources for the future will be a big challenge.

As tomorrow's decision-makers, today's students will play a big role in determining how well we meet that challenge. Complex legal, political, ecological, economic, and social ramifications will have to be considered. Few issues will have simple solutions, and resolving them will undoubtedly involve compromise. By introducing children to these ideas now, educators can help prepare them for the future.

## How a Sliver of Technology Tamed the Arctic

Archaeological evidence suggests that it wasn't until 14,000 to 13,000 years ago that humans migrated into North America by crossing from Siberia to Alaska via the Bering land bridge.

Most researchers agree that to survive in arctic and subarctic environments, ancient humans had to be able to make clothing that was generally form-fitting and relatively weather-tight. Such clothing was probably made by fastening pieces of animal hide together with sinew. The invention of the awl, a pointed implement used for stitching together animal skins for garments and other uses, was the technological breakthrough that most likely enabled ancient peoples to begin to colonize cold regions. The eyed needle, which evolved from the awl and is found on 30,000-year-old Russian campsites, would have allowed strong, weather-tight, and, in some cases, water-tight clothing seams to be made.

The importance of this small aspect of prehistoric technology—a simple needle—and its effect in terms of human occupation of the Western Hemisphere is almost unbelievable. Humans who settled in North and South America got there by migrating through the Arctic. Without the needle, they could not have done it.

Although it took roughly 15,000 years from the time that needles first appeared until humans were living in the Arctic, it can easily be said that this simple tool and those skilled in its use were responsible, in part, for the human occupation of the New World.

## FOR THE CLASSROOM

**P**lant growth is essential in the tundra environment, as plants are the primary food source for the rest of the consumers in the food chain. Plant growth and decomposition are constrained by the comparatively small amount of light and heat and by the very short but intense growing season. These limiting factors affect the ability of wildlife and plants to reproduce successfully and to maintain their populations over time.

The following activities demonstrate the effects of temperature and freezing on decomposition and the effect of permafrost on plant growth.



The honeycomb of polygonal shapes is the result of the seasonal churning of the ground above the underlying layer of permafrost.

### Temperature and Decomposition

**D**ecomposers are a crucial link in food chains and food webs because they return to the soil organic compounds that enhance plant growth. Decomposition is slower in the far North than in the rest of North America. Because decomposing matter takes longer to become integrated into the soil, plant growth may be limited by the lack of organic compounds in the soil. The slow process of soil formation in cool climates means that existing soil is slow to recover from disturbance by humans, animals, or the forces of erosion.

Have students try the following activity to help them understand the effect of cool temperatures on decomposition. Prior to the investigation, record students' hypotheses about how temperature relates to decomposition.

**Materials:** You will need four fresh apple slices, four sealable plastic containers, and a thermometer.

**Procedure:** Have students put an apple slice in each of the sealed containers, and place each container in a different environment: a cold place, a cool place, a warm place, and a hot place. Keep the light conditions reasonably similar in each environment. Then let a child lay the thermometer alongside each apple slice, and measure and record the temperature in each place. Have students examine the containers once each week and record the changes. What did they observe? How did cold affect the process of decay? (Cooler temperatures keep the microorganisms that decompose matter from multiplying quickly, which slows the rate of decomposition.)

### Freezing and Decomposition

**A**lthough decomposition is limited by the arctic climate, freezing and thawing actually speed access for bacteria and fungi to the insides of the cells of dead plants and animals. This is because water in tissue cells expands when it freezes, thus breaking cell walls and opening the inner cells to invasion once the tissue thaws. Nevertheless, the net effect of the arctic climate is to slow the rate of decomposition.

**Materials:** You will need four potatoes about the same size, two shallow dishes, a set of scales, and access to a freezer.

**Procedure:** Ask students to predict which potato will decay first: one that has been frozen and then thawed, or one that has never been frozen. Students should record their predictions and reasoning in their journals. Then have the children measure the mass of two potatoes and freeze them. The next day, thaw the potatoes in the open air and again measure their mass. Measure the mass of two potatoes that have not been frozen. How do they all compare? Have students squeeze a once-frozen and a never-frozen potato. Does water come out of both? Where did the water come from? (A living cell contains 85–90 percent water. When water inside the cell freezes and expands, the cell walls break. Thus the once-frozen potato releases more water than the never-frozen potato.) Next, have the class place in two labeled dishes the once-frozen potato and the never-frozen potato that were not squeezed. Keep both containers in the same location. Students should then observe and keep a daily record of changes in the potatoes for two weeks. (The once-frozen potato should decompose at a faster rate because when the water in its tissue cells froze and expanded, breaking the cell

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Large blocks of tundra-covered sediment, bounded by ice-wedge polygons, collapse into the Beaufort Sea as a result of mechanical and thermal erosion of the ice-rich sediment by wave action.

walls, the inner cells were opened to invasion once the tissue thawed.)

### Heaving and Thawing

**P**ermafrost, or permanently frozen ground, underlies all lowland tundra areas (except large lakes and rivers) in the Arctic. When present, permafrost and seasonal frost play an important part in shaping tundra lands and ecosystems. Permafrost prevents plant roots from penetrating deeply into the soil and leads to unstable growth—without a strong anchorage, even large plants could be ripped out of the ground by the wind.

Permafrost also retards the percolation and infiltration of ground water into the soil, and in some low-lying areas, can lead to shallow, water-covered formations known as peat bogs. Water-saturated soils and peat bogs restrict the variety of supportable life-forms in the tundra. The following investigation gives students an opportunity to observe the effects of permafrost on soil.

**Materials:** You will need two shallow baking pans, a sealable plastic container, soil, tap water, a fork, a tablespoon, and access to a freezer.

**Procedure:** Day 1—Have students completely fill a plastic container with tap water and seal it securely with a lid. Ask students to predict what will happen after the water-filled container has been in the freezer for several hours. Then, have the children put moist soil to a depth of about 5 cm into each of the two pans. Ask students what they think will happen when a soil-filled pan has been in the freezer for several hours. Place both the water-filled container and one of the soil-filled

pans in a freezer overnight. Put the other soil-filled pan aside.

Day 2—Explain to students that *permafrost* is a word used to describe soil that is frozen year-round. Ask the class how they think permafrost might differ from unfrozen soil. Ask them to think about the following questions:

- Would permafrost be warmer or colder than regular soil?
- Would it be harder or softer?
- Would it soak up more or less water?
- Would it take up more or less space?

Next, retrieve the pan of soil from the freezer and have students test their predictions by comparing the frozen soil with the unfrozen soil set aside the previous day. Ask a student to find out which soil is harder by using a fork. Next, have students pour a spoonful of water first on the frozen soil and then on the unfrozen soil. What happens to the water? Does one type of soil soak it up more readily? Remove the water-filled container from the freezer. Ask students what made the container's sides push out or break. Explain that water expands when it freezes. There was not enough space in the plastic container to hold the water once it had frozen and expanded. Using the information gathered from this lesson, ask the children to answer



Few people would identify this verdant vista as a part of arctic Alaska.

the following question: "Why does a road break, buckle, and form potholes in the spring?" (When water seeps into cracks in rocks and then freezes with falling temperatures, it expands and forces the rock to break into smaller parts. Thus, ice wedging occurs. Rocks are no different from city streets in this regard.)

These activities were adapted with permission from *Alaska's Tundra and Wildlife: Alaska Wildlife Curriculum Teacher's Guide*, published in 1995 by the Alaska Department of Fish and Game.

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### Extended Learning

Drilling for oil in ANWR would help the United States become less dependent on oil from other countries. Oil companies say they have developed special building techniques, used in other arctic regions, to reduce the effects of construction on the environment and avoid harming the region's wildlife. However, many people think that drilling for oil will damage the arctic ecosystem beyond repair, pointing out that in other arctic regions where oil wells have been drilled, toxic wastes have been released into the environment. Shipping the oil also can cause environmental problems, as was painfully evident after the 1989 *Exxon Valdez* spill.



In a wolf pack, only one pair has young but the entire pack works to feed and protect the pups.

After researching this issue, have students consider the pros and cons of drilling for oil along the arctic coast of ANWR. With such an activity, you might ask them to assume the role of a member of Congress and to argue either in favor of or against drilling in the refuge, or you might have each student write a speech presenting his or her reasoning.

### About the Authors

Jeff Brune is the environmental education coordinator for the Bureau of Land Management (BLM) in Alaska. Archaeologists Robert King, Mike Kunz, and Richard Brook are actively involved with the BLM's cultural resources programs. Mary Tisdale is the national coordinator for the BLM's environmental education and volunteer programs.

### Acknowledgments

Special thanks to David Mech, National Biological Survey; Phil Garrett, Deputy Refuge Manager, Arctic National Wildlife Refuge, Fish and Wildlife Service; Susan Holly, Gates of the Arctic National Park and Preserve, National Park Service; Harvey Hefferman, Arctic National Wildlife Refuge, Fish and Wildlife Service; Frankie Barker, Executive Director, Alaska Natural History Association; Colleen Matt, Program Director of the Alaska Department of Fisheries and Game; Grant Spearman of the Simon Paneak Museum; and to the following employees of the Department of the Interior: Jeremy Brodie, Connie Adkins, Jeff Denton, Shelly Fischman, Mike Scott, Bruce Seppi, Jim Sisk, Van Waggoner, and the staff of the Department of the Interior library.

### Resources

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The following booklets, developed by the Alaska Department of Fish and Game, are available for purchase: *Alaska's Tundra and Wildlife* (\$13.95); *Alaska's Forests and Wildlife* (\$13.95); *Wildlife for the Future* (\$13.95); and *Alaska's Ecology* (\$12.95). Each contains relevant background information, lesson plans, activity sheets, and interdisciplinary hands-on activities. Another booklet, *Alaska Ecology Cards* (\$6.99), is required for some of the activities and contains 270 illustrated cards with biological information about arctic animals and plants. These materials can be ordered from Circumpolar Press, Box 221944, Anchorage, AK 99522; tel. 907-248-9921.

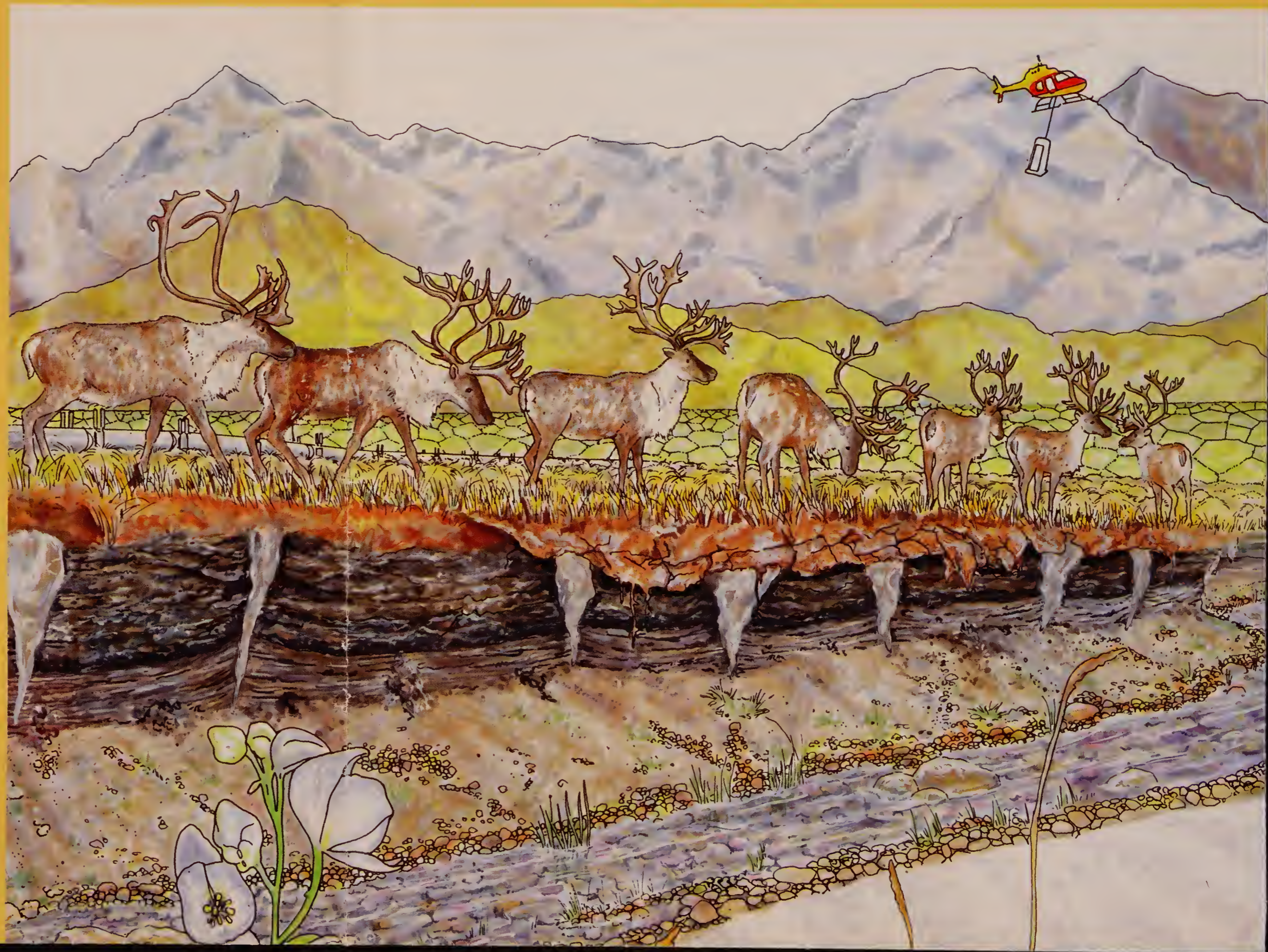


# Northern Exposures



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Artwork and associated research by Shelly Fischman

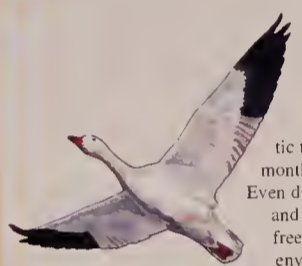
# Northern Exposures



## Surviving the Arctic Tundra: A Look at Cold-Weather Adaptations

By Jeff Brune

To keep warm on a cold day, you might pile on extra clothing or have a cup of hot chocolate. The nose bot fly of the frigid Arctic takes a decidedly different approach to staying warm. It takes refuge in the warm, steamy nose of a caribou. Once in the nostril, the fly withstands the snorts of the irritated animal and quickly deposits its wormy offspring. The maggots then crawl through the caribou's nose passages and settle in its throat, where they spend the winter warmed by the caribou's body heat and feed off its tissues. When spring arrives, the well-fed maggots are coughed up or sneezed to the ground, where they turn into adult flies and begin the cycle again.



**Snow goose.** Attracted by plentiful food, endless hours of daylight in which to eat, and a comparative lack of predators, snow geese and many other migrating birds flock to the tundra during the summer months.

Keeping warm is no easy task on the arctic tundra, where winter lasts almost nine months and temperatures can plunge to -55°C. Even during the brief summer, when the land thaws and the sun never sets, a sudden snowstorm can freeze everything. Constant high winds rob the environment of moisture and have a sandblasting effect, propelling sharp ice crystals and gritty dust that would tear a common houseplant to shreds. When the growing season lasts only 10-14 weeks and the soil has few nutrients, it's not easy for plants to make food. Similarly, when the sun sets for more than two months and the only light to hunt by comes from the moon or the eerie shimmer of the northern lights, animals have a hard time finding sustenance.

Despite such difficult conditions, life manages to survive in the Arctic because the plants and animals that live there have special traits, or adaptations, that make them especially suited for the cold, the persistent wind, and the brief growing season. These unique adaptations can be physical traits (such as warm fur), behaviors (such as hibernation), or physiological traits (such as the chemical processes that allow certain arctic plants to make food in low temperatures).

### Keeping Warm

Life-forms on the tundra have devised numerous ways of dealing with the arctic chill.

Many animals avoid the cold altogether. Millions of birds that flock to the tundra during the summer months fly south to warmer climates during the winter. Vast herds of caribou also leave the tundra in the winter and head for the protective cover of northern forests, although some caribou remain on the tundra through the winter months.

The hardy residents that stay in the Arctic year-round have developed special adaptations to brave the chill.

Musk oxen, for example, have two layers of protective fur. The outer layer is made of long hairs that protect the animal from wind and water. The woolly inner layer of fur traps air next to the body. Body heat warms the air, keeping the musk ox cozy even at -40°C! Other furry arctic animals include brown bears, caribou, wolves, ground squirrels, foxes, and hares.

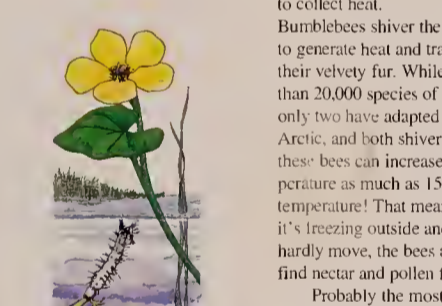


**Saxifrage.** Like many arctic plants, saxifrage grows low to the ground, where it absorbs heat radiated from the soil in the summer and is protected from winds and wind-borne ice by a blanket of snow in the winter.

Plants shelter themselves from the arctic elements by growing low to the ground. In the arctic summer, the dark-colored ground absorbs energy from the sun, so plants grow close to the warm ground rather than towering above it. In the winter, snow blankets and protects arctic plants from the wind and cold. Any twigs that do extend above the snow are slowly ground down by the sharp ice and snow blowing along the surface.

Insects battle the cold in many intriguing ways. All insects are cold-blooded and even on a summer arctic day, the chill in the air can make it difficult for them to move, let alone fly. So insects first need to warm up. Billions of mosquitoes, gnats, gnats, crane flies, and hover flies warm up by basking in the sun, often in the middle of a flower, such as the arctic dryad or arctic poppy.

Certain butterflies, such as *Polaris fritillary*, spread their wings and point them at the sun like solar panels to collect heat. Bumblebees shiver their flight muscles to generate heat and trap the warmth in their velvety fur. While there are more than 20,000 species of bees worldwide, only two have adapted to life in the Arctic, and both shiver. Amazingly, these bees can increase their body temperature as much as 15°C above the air temperature! That means that even when it's freezing outside and most insects can hardly move, the bees are flying out to find nectar and pollen for their colony.



**Marsh marigold, nose bot fly, and mosquito larvae.** The marsh marigold's bowl-shaped flowers follow the sun and focus light in toward the pollen and seed portion of the plant. Like all insects, the nose bot fly is cold-blooded and often warms up by basking in flowers. Mosquitoes take advantage of the tundra's large areas of standing water to deposit their eggs. Once the larvae emerge, they immediately begin feeding on bacteria, microscopic plants, and pollen.

Even birds have responded similarly to the cold, developing thick layers of feathers. The willow ptarmigan, for example, has water-repellent outer feathers in addition to inner feathers. These birds, which live year-round in the Arctic, even grow feathers on the soles of their feet! These feathers keep feet warm and double as shelter for wildlife but create a tricky surface for people to traverse on foot.

Along the stream, wedges of ice cut into the permafrost below. These wedges form in cracks and grow slowly, helping to create the polygons of the patterned ground illustrated in the distance. Also visible at the top of the stream cut, and partially insulating the exposed permafrost, is a flap of vegetation and soil. It began to drape down toward the streambed after the soil supporting it was eroded by the stream. Ice also is responsible for another prominent feature of the tundra, the



**Brown (grizzly) bear.** Thick fur insulates this bear from the cold and affords it some protection from insects in the summer. Hibernation and a willingness to eat just about anything help the grizzly to survive the arctic climate.

### Investigation: Size and Heat

**Background:** Biologists have noticed that many tundra birds and mammals are larger and have smaller appendages than do similar species living in warmer environments. Tundra hares, for example, are among the largest hares and have shorter ears and legs than do desert hares (called jackrabbits). Similarly, arctic foxes have shorter ears than do desert kit foxes. Even lemmings are larger and have smaller ears and tails than do most other mouse-like animals. Large size and short appendages are adaptations that reduce heat loss and resist the cold.

The amount of heat loss increases as the proportion of exposed surface area to body mass increases. Since that proportion is greater in small animals, they lose heat more quickly. An animal with long legs, ears, or a tail has more surface area than an animal of the same size that has shorter appendages.

However, in some cases, small size can be an adaptation for survival on the tundra. Why? A small organism can survive on less food than can a large organism of the same species. Shrews, the smallest of all mammals, thrive in the tundra of arctic Alaska.

**Materials, Part 1:** Each work station should have two laboratory-type thermometers; large and small containers made of the same material (two tin cans or two plastic jugs, for example); hot tap water; access to cold temperatures outdoors or to a refrigerator; the Adaptation Cards (pictured below); and a posted set of instructions.

**Materials, Part 2:** Each work station should have one pair of latex gloves; several rubber bands; two laboratory-type thermometers; warm water; graduated cylinders or beakers; two containers of at least 250 mL capacity; access to cold temperatures outdoors or to a refrigerator; the Adaptation Cards (pictured below); and a posted set of instructions.

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Which will lose heat and grow cold faster, a large object or a small object? Test your hypothesis with the following investigation.

1. Fill the large and small containers with hot water. Measure and record the water temperature in each container.
2. Place both containers outside or in a cold place for 15 minutes. Again, measure and record the water temperature in each container.
3. Find the difference between the starting and ending readings for both containers. Which container's contents cooled down more? Did your prediction match your results?
4. Based on what you found out about the relationship between cooling and the size of the objects, do you think animals living in tundra environments would be larger or smaller than animals living in warm environments?
5. Using the Adaptation Cards, compare the sizes of the animals in each pair. Which animals are larger—the ones living on the tundra or the ones living in a warm environment? Which moose do you think would be larger, one native to Wyoming, or one native to Alaska? Try to find out if you are correct.

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The tundra's human population is sparse. Permanent settlements are few and far between, most being Inuit villages along the coast. Seasonal populations include scientists and naturalists. Transportation is difficult and often accomplished by light aircraft and helicopters. But, as indicated by the ancient arrowhead pictured, our ancestors traveled the area on foot, as long as 10-12 thousand years ago, hunting and making a life for themselves.

## Tundra Adaptations

### Instructions: Part 2

Which one do you think keeps your hands warmer, mittens or gloves? Test your hypothesis with the following investigation.

1. While wearing goggles, close off each of the five finger compartments in one of the gloves. Be sure the rubber bands are tight. This will be called the "mitten." The other glove will be called the "normal glove."
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5. Place both gloves in a cold place (a refrigerator, or outdoors if the temperature is cold enough), near each other, but not touching. Wait 15 minutes. Pour the water from the "mitten" into one container and the water in the "normal glove" into another container. Measure and record the temperature of the water in both containers.
6. In which glove did the water temperature decrease? How would you explain this difference? Next time it's cold and you go outside, will you wear mittens or gloves to keep your hands warm?
7. Now, think about animals living on the tundra. The blood in their bodies is like water in the gloves. Their toes, ears, and tails are like the fingers in the gloves. Considering what you learned from this exercise, which animal do you think would stay warmer in the tundra, one with long ears, toes, and tail, or one with short ears, toes, and tail?
8. Looking at the Adaptation Cards, compare the appendages (ears, tails, legs, and so on) of the arctic animals to those of the warm-climate animals. Give a reason for the differences you observe.



**Ground squirrel.** Thick fur protects this squirrel from the cold during hibernation. Prior to hibernation, the squirrel stores food to be eaten in the spring before new plant growth appears.

### Finding Food

The menu of available food in the Arctic changes with the seasons. The summer is like an all-you-can-eat buffet. The sun shines 24 hours a day, snow melts, and plants soak up the sun and grow rapidly. Tundra ponds thaw and become thick with water plants, insect larvae, and shellfish. Millions of ducks, geese, loons, gulls, sandpipers, and other migrating birds return, ready to nest, have young, and gorge themselves. Great herds of caribou also arrive from their winter homes to give birth and feast on plants. Wolves, bears, and other predators also take part in the foodfest. And let's not forget the mosquitoes, sucking blood from any animal, large or small.

The winter menu, on the other hand, is bleak. There is little sunlight, plants are snow-covered, and the summertime crowds have left. The hardy, year-round residents are left to forage for what little food remains. Microscopic organisms, plants, and insects go into a state of dormancy—they stop growing, moving, and/or breathing—so they don't need food.

Because birds and mammals breathe, they can't go completely dormant. Instead, animals like the grizzly bear and arctic ground squirrel hibernate. Hibernating animals become inactive, their breathing and heart rates slow, and they have little need for food energy beyond that supplied by stored fat.

Another food-related adaptation is moving or migrating for food. This is the strategy of millions of birds that arrive in the summer when food is plentiful and leaves in the winter, when food runs out. The arctic tern, considered to be the world's greatest traveler, flies from the Antarctic Ocean near the South Pole all the way to the Arctic to spend the summer breeding and nesting.

Caribou also migrate. Living on the tundra during the summer, they feed mostly on grasses, sedges, birch, and willow. In the winter, many caribou migrate to the moist northern forests where they feed on lichen, a plant composed of fungus and algae.

Plants, too, have adapted to the Arctic. They make food faster and at lower temperatures than do plants in warmer climates. The alpine saxifrage, for

example, has leaves that survive the winter without shriveling up. Once the spring sun hits the leaves, they begin to make food for the plant right away, thus providing a clear advantage over plants that must wait for new leaves to break out and unfurl.

### Producing and Protecting Young in the Arctic

Of course, there is more to life on the tundra than just keeping warm, finding food, and avoiding predators. Animals have to raise their young, too, and do so quickly, before the short summer ends.

Birds that migrate to the Arctic have to find mates, build nests, lay eggs, hatch them, and feed their young to the point where they can fly—all in 10-14 weeks! So why do millions of birds fly from all over the world to the Arctic? First, food is plentiful, especially high-energy foods like insects that young birds need. There are also fewer predators



**Arctic fox.** Thick fur provides warmth for this arctic resident, changing color from summer (red-brown) to winter (white). Compared to foxes that live in warmer climates, the arctic fox has smaller ears, minimizing loss of body heat.

than in the south. And parents have more "working hours," provided by the constant sunlight, in which to feed their young.

No matter what the climate, it takes a lot of energy to have young, feed them, and raise them. Because food can be scarce even in the arctic summer, most animals have adapted the ability to adjust the number of young they produce, depending on environmental conditions. For example, if the snow remains in the spring longer than usual, food sources remain covered. Some migratory birds, such as geese and swans,

respond by laying fewer eggs or none at all. Meat-eating animals like arctic foxes, weasels, and snowy owls will produce fewer young when their main food source—lemmings—is scarce. Caribou and musk oxen put on a lot of fat in the late summer, but not just to prepare for winter food shortages. These animals also need large amounts of food energy for the mating season and birth process. Males need energy for doing

battle with antlers or horns in an effort to win mating rights. Pregnant females need energy to sustain developing fetuses over the winter, and to care for the calves born in the spring. Even mosquitoes need energy to have young. To get that energy, female mosquitoes drink blood. In fact, most female mosquitoes found worldwide must have a blood meal before they can lay eggs. Arctic species, however, can lay at least a few eggs even if they can't get blood, because they build up enough food reserves for this purpose as larvae. Of course, these mosquitoes can lay many more eggs after a quick slurp from some unsuspecting animal. And slurp they do, by the billions. In just one week's time, a single caribou can lose two liters of blood to mosquitoes. The insects don't get off scot free, however; yellow jackets catch mosquitoes on the wing and feed them to their grubs.

With the summer so short, most plants on the arctic tundra do not have enough time to make seeds. Instead, the plants spread vegetatively, without producing seeds. For example, some plants grow runners above ground or below ground that reach out and form new, separate plants. Others grow little buds that fall off, blow away in the wind, and start to take root once they land in a good growing spot. Those plants that do produce seeds rely heavily on mosquitoes and other insects of the far north to facilitate pollination. Some plants, like the Pallas's wallflower and prickly saxifrage, use the high arctic winds to their advantage. At the beginning of summer, for example, the plant stalks are short. Once the seeds are ready, the stalks grow tall, pushing the seed pods up above the fall snow cover. The high winds blow the seeds over the slippery, crusty snow, sending them over a wide area.

Life in the Arctic goes on, despite the brutally tough conditions. Faced with bone-chilling temperatures, relentless winds, and dramatic changes in the seasons, life does one thing: It adapts.



**Snowshoe hare.** This arctic animal congregates in large groups, which helps to create confusion when the hares scatter before the onslaught of predators. The hare's large, padded feet act as snowshoes, and its coat changes color from winter (white) to summer (brown) to camouflage it from predators. Small ears help to reduce loss of body heat.



**Jackrabbit.** This warm-climate creature stays the same color year-round because there is not much seasonal variation in its environment. Note the large ears; the more heat lost through radiation from the ears, the better.



### Arctic Ground Squirrel

This squirrel, typically 20 to 32 centimeters long and weighing one kilogram, has thick fur. It can hibernate for several months, living off stored fat.



### Antelope Ground Squirrel

This warm-climate squirrel, typically 15 centimeters long and weighing 90 grams, has short fur and a fairly long tail. It must eat year-round but can survive for weeks without water.



### Arctic Fox

This fox, usually weighing 3-6 kilograms, has long, warm fur that turns white in winter and short ears.



### Kit Fox

This desert fox, usually weighing 1-3 kilograms, is light brown year-round and has large ears.



### Snowshoe Hare

This mammal has long, dense fur that turns white in winter and fairly short ears.



### Desert Jackrabbit

This mammal has short fur that stays light brown year-round and very large ears.



### Collared Lemming

This arctic mammal has thick fur that turns white in winter and a short tail, small ears, and short legs.



### Kangaroo Rat

This desert mammal has short fur that stays light tan year-round and a long tail, long ears, and long legs.



### Snowy Owl

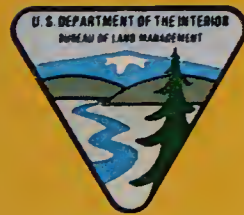
This large, white bird feeds on small mammals. It nests on the ground.



### Great Horned Owl

This large, brown bird feeds on small mammals. It builds stick nests in trees.

# Northern



## Surviving the Arctic Tundra: A Look at Cold-Weather Adaptations

By Jeff Brune

To keep warm on a cold day, you might pile on extra clothing or have a cup of hot chocolate. The nose bot fly of the frigid Arctic takes a decidedly different approach to staying warm. It takes refuge in the warm, steamy nose of a caribou. Once in the nostril, the fly withstands the snorts of the irritated animal and quickly deposits its wormy offspring. The maggots then crawl through the caribou's nose passages and settle in its throat, where they spend the winter warmed by the caribou's body heat and feed off its tissues. When spring arrives, the well-fed maggots are coughed up or sneezed to the ground, where they turn into adult flies and begin the cycle again.

Keeping warm is no easy task on the arctic tundra, where winter lasts almost nine months and temperatures can plunge to  $-55^{\circ}\text{C}$ . Even during the brief summer, when the land thaws and the sun never sets, a sudden snowstorm can freeze everything. Constant high winds rob the environment of moisture and have a sandblasting effect, propelling sharp ice crystals and gritty dust that would tear a common houseplant to shreds. When the growing season lasts only 10–14 weeks and the soil has few nutrients, it's



**Snow goose.** Attracted by plentiful food, endless hours of daylight in which to eat,



**Saxifrage.** Like many arctic plants, saxifrage grows low to the ground, where it absorbs heat radiated from the soil in the summer and is protected from winds and wind-borne ice by a blanket of snow in the winter.

enough to stay warm, arctic animals seek shelter. For example, to escape the cold winter winds, the ptarmigan takes flight and dives into a drift of soft snow. The snow blankets the land and acts as a good insulator, trapping heat that comes from the ground. Diving from the air, the ptarmigan leaves no tracks for predators to follow.

Plants shelter themselves from the arctic elements by growing low to the ground. In the arctic summer, the dark-colored ground absorbs energy from the sun, so plants grow close to the warm ground rather than towering above it. In the winter, snow blankets and protects arctic plants from the wind and cold. Any twigs that do extend above the snow are slowly ground down by the sharp ice and snow blowing along the surface.

Insects battle the cold in many intriguing ways. All insects are cold-blooded and even on a summer arctic day, the chill in the air can make it difficult for them to move, let alone fly. So insects first need to warm up. Billions of mosquitoes, midges, gnats, crane flies, and hover flies warm up by basking in the sun.

Even birds have responded similarly to the cold, developing thick layers of feathers. The willow ptarmigan, for example, has water-repellent outer feathers in addition to inner feathers. These birds, which live year-round in the Arctic, even grow feathers on the soles of their feet! These feathers keep feet warm and double as snowshoes to prevent the bird from sinking into the snow.

When fur or feathers are not



**Brown (grizzly) bear.** Thick fur insulates this bear from the cold and affords it some protection from insects in the

The front of this foldout depicts the Alaskan tundra in late spring. As the snow melts, the region's flora and fauna become more visible and active. Purple monkshood, bog rosemary (red), and tundra rose (yellow) grow and flower; as do many varieties of moss and lichen (lower right). Often, plants in the nutrient-poor soil benefit from the spot fertilization of animal droppings or the decayed remains of dead animals and plants. Tussocks of sedges and grasses, which tend to grow in clumps (center right), provide food and shelter for wildlife but create a tricky surface for people to traverse on foot.

Along the stream, wedges of ice cut into the permafrost below. These wedges form in cracks and grow slowly, helping to create the polygons of the patterned ground illustrated in the distance. Also visible at the top of the stream cut, and partially insulating the exposed permafrost, is a flap of vegetation and soil. It began to drape down toward the streambed after the soil supporting it was eroded by the stream. Ice also is responsible for another prominent feature of the tundra, the

## Tundra Adaptations

### Investigation: Size and Heat

**Background:** Biologists have noticed that many tundra birds and mammals are larger and have smaller appendages than do similar species living in warmer environments. Tundra hares, for example, are among the largest hares and have shorter ears and legs than do desert hares (called jackrabbits). Similarly, arctic foxes have shorter ears than do desert kit foxes. Even lemmings are larger and have smaller ears and tails than do most other mouse-like animals. Large size and short appendages are adaptations that reduce heat loss and resist the cold.

The amount of heat loss increases as the proportion of exposed surface area to body mass increases. Since that proportion is greater in small animals, they lose heat more quickly. An animal with long legs, ears, or a tail has more surface area than an animal of the same size that has shorter appendages.

However, in some cases, small size can be an adaptation for survival on the tundra. Why? A small organism can survive on less food than can a large organism of the same species. Shrews, the smallest of all mammals, thrive in the tundra of arctic Alaska.

**Materials, Part 1:** Each work station should have two laboratory-type thermometers; large and small containers made of the same material (two tin cans or two plastic jugs, for example); hot tap water; access to cold temperatures outdoors or to a refrigerator; the Adaptation Cards (pictured below); and a posted set of instructions.

# Exposures

pingo (the hill on the far edge of the polygonal ground with red soils exposed). Essentially an ice-filled blister, a pingo can attain a height of more than 30 meters. Eventually the summit can rupture and thaw, creating a water-filled crater lake or collapsing the structure altogether.

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The tundra's human population is sparse. Permanent settlements are few and far between, most being Inuit villages along the coast. Seasonal populations include scientists and naturalists. Transportation is difficult and often accomplished by light aircraft and helicopters. But, as indicated by the ancient arrowhead pictured, our ancestors traveled the area on foot, as long as 10–12 thousand years ago, hunting and making a life for themselves.

## Adaptations

### Instructions: Part 2

Which one do you think keeps your hands warmer, mittens or gloves? Test your hypothesis with the following investigation.

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Because birds and mammals breathe, they can't go completely dormant; instead, animals like the grizzly bear and arctic ground squirrel hibernate. Hibernating animals become inactive, their breathing and heart rates slow, and they have little need for food energy beyond that supplied by stored fat.

Another food-related adaptation is moving or migrating for food. This is the strategy of millions of birds that arrive in the summer when food is plentiful and leave in the winter, when food runs out. The



**Arctic fox.** Thick fur provides warmth for this arctic resident, changing color from summer (red-brown) to winter (white). Compared to foxes that live in warmer climates, the arctic fox has smaller ears, minimizing loss of body heat.

than in the south. And parents have more "working hours," provided by the constant sunlight, in which to feed their young.



**Kit fox.** A creature of warmer latitudes and less seasonal change, this fox's fur does not change color with the seasons. And, unlike the arctic fox, the kit fox's ears are rather large. For this animal, heat retention isn't desirable, and the more of it lost by radiating out from those ears, the better.

No matter what the climate, it takes a lot of energy to have young, feed them, and raise them. Because food can be scarce even in the arctic summer, most animals have adapted the ability to adjust the number of young they produce, depending on environmental conditions. For example, if the snow remains in the spring longer than usual, food sources remain covered. Some migratory birds, such as geese and swans, respond by laying fewer eggs or none at all. Meat-eating animals like arctic foxes, weasels, and snowy owls will produce fewer young when their main food source—lemmings—is scarce.

Caribou and musk oxen put on a lot of fat in the late summer, but not just to prepare for winter food shortages. These animals also need large amounts of food energy for the mating season and birth process. Males need energy for doing

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Even mosquitoes need energy to have young. To get that energy, female mosquitoes drink blood. In fact, most female mosquitoes found worldwide must have a blood meal before they can lay eggs. Arctic

## SCIENCE & CHILDREN

Jeff Brune is the environmental education coordinator for the Bureau of Land Management (BLM) in Alaska. Shelly Fischman is a program specialist and illustrator for the BLM. Copyright 1996 by the National Science Teachers Association



and a comparative lack of predators, snow geese and many other migrating birds flock to the tundra during the summer months.

not easy for plants to make food. Similarly, when the sun sets for more than two months and the only light to hunt by comes from the moon or the eerie shimmer of the northern lights, animals have a hard time finding sustenance.

Despite such difficult conditions, life manages to survive in the Arctic because the plants and animals that live there have special traits, or adaptations, that make them especially suited for the cold, the persistent wind, and the brief growing season.

These unique adaptations can be physical traits (such as warm fur), behaviors (such as hibernation), or physiological traits (such as the chemical processes that allow certain arctic plants to make food in low temperatures).

## Keeping Warm

Life-forms on the tundra have devised numerous ways of dealing with the arctic chill.

Many animals avoid the cold altogether. Millions of birds that flock to the tundra during the summer months fly south to warmer climates during the winter. Vast herds of caribou also leave the tundra in the winter and head for the protective cover of northern forests, although some caribou remain on the tundra through the winter months.

The hardy residents that stay in the Arctic year-round have developed special adaptations to brave the chill.

Musk oxen, for example, have two layers of protective fur. The outer layer is made of long hairs that protect the animal from wind and water. The woolly inner layer of fur traps air next to the body. Body heat warms the air, keeping the musk ox cozy even at  $-40^{\circ}\text{C}$ ! Other furry arctic animals include brown bears, caribou, wolves, ground squirrels, foxes, and hares.



**Arctic tern.** These birds create their own "endless summer" by commuting between the Arctic and Antarctic, visiting each during periods of constant daylight.

often in the middle of a flower, such as the arctic dryad or arctic poppy.

Certain butterflies, such as *Polaris fritillary*, spread their wings and point them at the sun like solar panels



**Marsh marigold, nose bot fly, and mosquito larvae.** The marsh marigold's bowl-shaped flowers follow the sun and focus light in toward the pollen and seed portion of the plant. Like all insects, the nose bot fly is cold-blooded and often warms up by basking in flowers. Mosquitoes take advantage of the tundra's large areas of standing water to deposit their eggs. Once the larvae emerge, they immediately begin feeding on bacteria, microscopic plants, and pollen.

to collect heat.

Bumblebees shiver their flight muscles to generate heat and trap the warmth in their velvety fur. While there are more than 20,000 species of bees worldwide, only two have adapted to life in the Arctic, and both shiver. Amazingly, these bees can increase their body temperature as much as  $15^{\circ}\text{C}$  above the air temperature! That means that even when it's freezing outside and most insects can hardly move, the bees are flying out to find nectar and pollen for their colony.

Probably the most cold-hardy of all insects is the arctic woolly bear, a caterpillar that spends most of its 14-year life frozen solid. Even for a thumb-sized creature, this is no small feat. When body fluids freeze, they expand, form ice crystals, and damage cells and living tissues, most often killing the organism. The woolly bear combats the effects of freezing by producing special chemicals. During the fiercely cold arctic winters, these chemicals prevent ice from forming inside the cells of the caterpillar, even when ice does form in the space between cells, in the gut, and in the blood. This adaptation allows the woolly bear to withstand temperatures as low as  $-70^{\circ}\text{C}$ .

summer. Hibernation and a willingness to eat just about anything help the grizzly to survive the arctic climate.

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3. Find the difference between the starting and ending readings for both containers. Which container's contents cooled down more? Did your prediction match your results?
4. Based on what you found out about the relationship between cooling and the size of the objects, do you think animals living in tundra environments would be larger or smaller than animals living in warm environments?
5. Using the Adaptation Cards, compare the sizes of the animals in each pair. Which animals are larger—the ones living on the tundra or the ones living in a warm environment? Which moose do you think would be larger, one native to Wyoming, or one native to Alaska? Try to find out if you are correct.



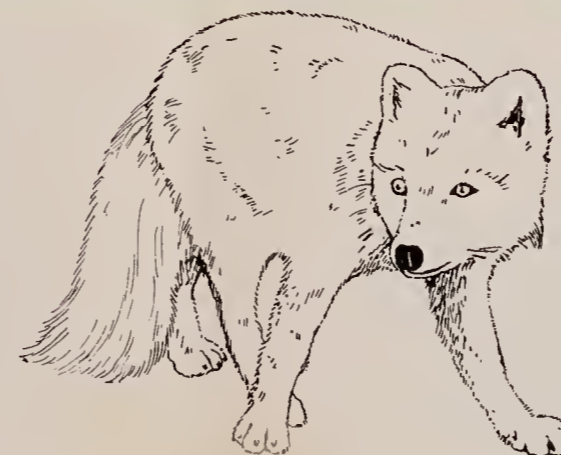
## Arctic Ground Squirrel

This squirrel, typically 20 to 32 centimeters long and weighing one kilogram, has thick fur. It can hibernate for several months, living off stored fat.



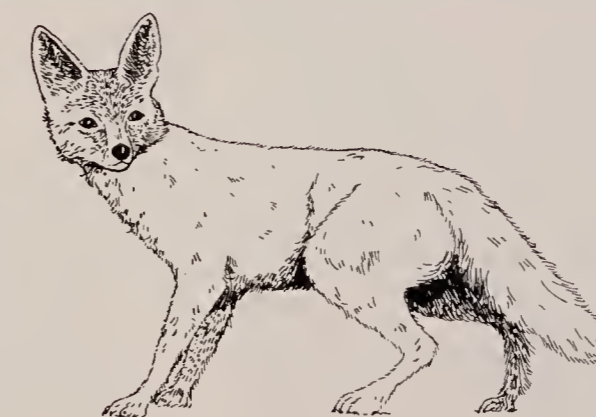
## Antelope Ground Squirrel

This warm-climate squirrel, typically 15 centimeters long and weighing 90 grams, has short fur and a fairly long tail. It must eat year-round but can survive for weeks without water.



## Arctic Fox

This fox, usually weighing 3–6 kilograms, has long, warm fur that turns white in winter and short ears.



## Kit Fox

This desert fox, usually weighing 1–3 kilograms, is light brown year-round and has large ears.



## Snowshoe Hare

This mammal has long, dense fur that turns white in winter and fairly short ears.

would you explain this difference? Next time it's cold and you go outside, will you wear mittens or gloves to keep your hands warm?

7. Now, think about animals living on the tundra. The blood in their bodies is like water in the gloves. Their toes, ears, and tails are like the fingers in the glove. Considering what you learned from this exercise, which animal do you think would stay warmer in the tundra, one with long ears, toes, and tail, or one with short ears, toes, and tail?

8. Looking at the Adaptation Cards, compare the appendages (ears, tails, legs, and so on) of the arctic animals to those of the warm-climate animals. Give a reason for the differences you observe.

## Teacher Wrap-up

In the first part of this investigation, students observe that the small container lost heat more quickly than did the large container. Heat loss increases as the proportion of exposed surface area to body mass increases. Since that proportion is greater for the small container than for the large one, the small container loses heat more quickly. In the second part of the investigation, students observe that heat loss is greater for the glove than for the mitten. This is because the glove has a greater surface area than does the mitten.

The Adaptation Cards can help students make the connection between their investigations and animal adaptations. Tundra birds and mammals are larger and have smaller appendages than do similar species in warmer environments and, therefore, retain heat better than do their desert counterparts.

These activities were adapted with permission from *Alaska's Tundra and Wildlife: Alaska Wildlife Curriculum Teacher's Guide*, published in 1995 by the Alaska Department of Fish and Game.

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example, has leaves that survive the winter without shriveling up. Once the spring sun hits the leaves, they begin to make food for the plant right away, thus providing a clear advantage over plants that must wait for new leaves to break out and unfurl.

## Producing and Protecting Young in the Arctic

Of course, there is more to life on the tundra than just keeping warm, finding food, and avoiding predators. Animals have to raise their young, too, and do so quickly, before the short summer ends.

Birds that migrate to the Arctic have to find mates, build nests, lay eggs, hatch them, and feed their young to the point where they can fly—all in 10–14 weeks! So why do millions of birds fly from all over the world to the Arctic? First, food is plentiful, especially high-energy foods like insects that young birds need. There are also fewer predators

for any place in the winter, when food is scarce. The arctic tern, considered to be the world's greatest traveler, flies from the Antarctic Ocean near the South Pole all the way to the Arctic to spend the summer breeding and nesting.

Caribou also migrate. Living on the tundra during the summer, they feed mostly on grasses, sedges, birch, and willow. In the winter, many caribou migrate to the moist northern forests where they feed on lichen, a plant composed of fungus and algae.

Plants, too, have adapted to the Arctic. They make food faster and at lower temperatures than do plants in warmer climates. The alpine saxifrage, for



*Snowshoe hare. This arctic animal congregates in large groups, which helps to create confusion when the hares scatter before the onslaught of predators. The hare's large, padded feet act as snowshoes, and its coat changes color from winter (white) to summer (brown) to camouflage it from predators. Small ears help to reduce loss of body heat.*



*Jackrabbit. This warm-climate creature stays the same color year-round because there is not much seasonal variation in its environment. Note the large ears; the more heat lost through radiation from the ears, the better.*

they land in a good growing spot.

Those plants that do produce seeds rely heavily on mosquitoes and other insects of the far north to facilitate pollination. Some plants, like the Pallas's wallflower and prickly saxifrage, use the high arctic winds to their advantage. At the beginning of summer, for example, the plant stalks are short. Once the seeds are ready, the stalks grow tall, pushing the seed pods up above the fall snow cover. The high winds blow the seeds over the slippery, crusty snow, sending them over a wide area.

Life in the Arctic goes on, despite the brutally tough conditions. Faced with bone-chilling temperatures, relentless winds, and dramatic changes in the seasons, life does one thing: It adapts.



## Desert Jackrabbit

This mammal has short fur that stays light brown year-round and very large ears.



## Collared Lemming

This arctic mammal has thick fur that turns white in winter and a short tail, small ears, and short legs.



## Kangaroo Rat

This desert mammal has short fur that stays light tan year-round and a long tail, long ears, and long legs.



## Snowy Owl

This large, white bird feeds on small mammals. It nests on the ground.



## Great Horned Owl

This large, brown bird feeds on small mammals. It builds stick nests in trees.